REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*
18/Jan/2002

2. REPORT TYPE
MAJOR REPORT

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE
LEO SATELLITE SERVICES-CAN A STARTUP PROVIDER SURVIVE

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
CAPT SCHLAK CHRISTOPHER G

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
UNIVERSITY OF COLORADO AT BOULDER

8. PERFORMING ORGANIZATION REPORT NUMBER
CI02-13

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
THE DEPARTMENT OF THE AIR FORCE
AFIT/CIA, BLDG 125
2950 P STREET
WPAFB OH 45433

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Unlimited distribution
In Accordance With AFI 35-205/AFIT Sup 1

DISTRIBUTION STATEMENT A:
Approved for Public Release -
Distribution Unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

20020204 086

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE		12	19b. TELEPHONE NUMBER *(Include area code)*

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

LEO Satellite Services – Can A Startup Provider Survive?

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1 Introduction

In 1958, President Dwight D. Eisenhower became the first person to send a voice transmission over an orbiting satellite when he sent his Christmas message over the SCORE satellite [25]. By 1962, Telstar 1 was providing real-time video between the United States and France [26] during its short 20-minute window of operation. The telecommunications industry would never be the same once space based telecommunications became a reality. Voice telephony came first, then video broadcasting, and now, two-way digital video broadcasting with IP over satellite data connections.

Satellite communication has entered into many facets of the telecommunications industry, but has it reached its limits? Many of the services being offered by today's leading satellite providers are in direct competition with less expensive terrestrial systems. The cost of designing, building, launching, operating, and maintaining a satellite or constellation of satellites is an enormous sum that must be spent before the service is ever offered to the public. With an increasing percentage of the market share converting to terrestrial based services, the following question should be asked of the current Low Earth Orbit (LEO) satellite service industry: Can a LEO startup service provider survive and make money in the current satellite service market?

2 Methodology

This paper will examine, through case studies, how LEO service providers attempted to deliver services worldwide, the costs related to their services, and the regulatory hurdles that needed to be overcome to begin service. Based on these case studies, a new LEO service company will be defined and examined for economic viability. This new model will look at specific markets and regulatory hurdles, use competitive analysis of terrestrial counterparts to determine barriers to entry, and examine risk factors involved in offering a LEO service. By analyzing the satellite market and requirements to deploy a new LEO service, this paper will attempt to show that LEO service providers can survive in the current telecommunications market.

3 Case Studies

3.1 Iridium, ORBCOMM, and Globalstar

Iridium, ORBCOMM, and Globalstar will offer a baseline for current satellite market trends. Table 1, shown on the next page, is a list of indicators that will be evaluated to determine the state of the LEO satellite service market. Definitions of each services' market, services offered, current status of the constellation, operating costs, and regulatory issues are highlighted.

3.2 Commonalities Within Case Studies

Technical barriers were a drastic limitation of all services. "Building fade" was a killer to Iridium and Globalstar. Since their frequencies were in the L-band, 2 GHz Mobile Satellite Service (MSS) spectrum, calls could not be completed when a subscriber was in a building. Any large obstruction, such as mountains or significant vegetation that weakens a line-of-site (LOS) communications would also terminate calls in progress [15]. ORBCOMM experienced "building fade" but to a lesser degree than Iridium or Globalstar.

TABLE 1

Categories	Iridium	ORBCOMM	Globalstar
Overview	Constellation of 66 LEO satellites designed to offer two-way voice commu-nication. First satellite communication system to successfully use Inter-Satellite-Links to complete an end-to-end connection [2].	Constellation of 35 LEO satellites [6] to provide global messaging service. Has operating licenses in over 50 countries, representing 90% of the globe's Gross National Product [10].	Constellation of 48 LEO satellites designed to provide continuous global coverage for voice and low speed data [19].
Market	Target industries: Aviation, construction, disaster relief, emergency, utilities, oil and gas exploration and government [3]. Coverage in all ocean areas, air routes, landmasses and the poles [5].	Mobile asset tracking and monitoring (70%) [12]. Future market includes: telemetry, person-to-person global messaging, stolen vehicle recovery, and two-way Internet e-mail [6].	Long-distance truckers, loggers, and fishermen who are out of cell range [20]. Industrial users: maritime, military, mining and oil exploration, and developing countries [21].
Services	Voice/Paging: 2.4 kbps. Data/Fax: 2.4 to 10 kbps [3].	Provides affordable global wireless data and messaging for commercial and personal uses [8].	Two-way voice and low speed data. Fixed service in areas with inadequate telephone infrastructure [10].
Op. Status	Providing voice and data services since March 2001 [1]. Currently operating with temporary licenses while the FCC processes their application [5].	Filed for bankruptcy in Sept 2000. New Orbcomm provides global data services through 31 satell-ites from the first gener-ation constellation [9].	Currently operating 38 gateways worldwide, servicing more than 100 countries on 6 continents [12].
Cost	Corporate: $25 million investment. $7 million per month to operate [1]. Subscriber: less than $1.50/minute. $900-$1500 per handset [5].	$7.5 million investment, $900k monthly operating expenses [9]. Each wireless device costs $995. Charges are $0.01 per character [7].	Initial cost of system was $3 billion for space and ground segment [11]. Tri-mode phone costs $900 [13]. Airtime ranges from $0.89-$1.29/minute.
Regulation	In the process of transfer-ring all of the licenses of the old Iridium LLC to the new Iridium [4]. Currently operating while the license transfer process proceeds.	New Orbcomm has regulatory approval in virtually every major economic market in the world [9].	Globalstar began service as a non-common carrier within the U.S. in 1999 and abides by ITU regulations for spectrum reuse in various ITU regions [14].

Offering a global service meant deconflicting spectrum around the world. Overlap with other company's satellite frequencies required Globalstar and Iridium to modify their original implementation plans. In addition to the two aforementioned problems - satellite failures, lower than expected market demand, varying business strategies, and eventual bankruptcy (except for Globalstar) caused investors to cringe at the thought of investing in new LEO services. Table 2 gives a snapshot of the three companies, their pertinent details, and equivalent terrestrial competitors.

TABLE 2

Satellite Constellation	Iridium	Orbcomm	Globalstar
Constellation Type	Big LEO	Little LEO	Big LEO
Number of Satellites	66	35	48
Terrestrial Counterparts	Cellular	Paging	Cellular
Uplink Frequency	1 - 3 GHz	< 500 MHz	1 - 3 GHz
Subscriber Costs (Airtime)	$1.50/min	< $0.01 per character	$1.29/min
Subscriber Costs (Handset/Terminal)	$900 - $1600	$995	$900 - $1200
Data Rates	10 kbps	4.8 kbps	9.6 kbps
Filed for Bankruptcy	Y	Y	N
Corporate Debt	$25 M	$7.5 M	$219 M
Revenues Per Year *	$1.5 M **	$3 M	$3.5 M

* Corporate SEC Filings – Form 10-Q

** Revenues for Iridium LLC in 2000 before bankruptcy filing

4 Future LEO Satellites Constellations

Based on the previous constellation failures, the decision to plan, build, launch, and operate a LEO satellite constellation as its primary network to offer services becomes questionable. In response to the tremendous costs involved in the aforementioned LEO companies due to the large number of satellites and ground stations, this paper attempts to create a LEO constellation where costs would be lower and the company could survive and make money. This paper will also examine the possibility of additional capacity being leased from other LEO or GEO satellite systems.

5 The Simulated LEO Model

To lower the initial costs that a LEO company incurs, a simulation is used to create a constellation that provides coverage over a specific geographical region instead of the entire globe. The model is based on the Ellipso constellation [16] and is modeled by using the SaVi satellite simulation software.

The Ellipso model was chosen because of the excellent coverage of the world's population and because of the lower number of satellites required for service. Since Ellipso has fewer satellites to provide global coverage, that equates to a lower initial cost, a major factor to the success of a startup LEO service provider.

5.1 The Ellipso Constellation

The model is derived from the concept first put forth by Ellipso. It is a concept constellation since they have yet to launch any satellites. Ellipso's concept constellation is made up of satellites in two types of orbits: Concordia and Borealis. The Concordia constellation (Figure 1) is comprised of seven satellites in two equatorial planes, one circular and one elliptical, at an altitude of 8,050 km. The Borealis constellation (Figure 2) is comprised of two elliptical planes inclined at 116.6 degrees with five satellites per plane. The Borealis orbits have their perigee of 633 km over the southern hemisphere and apogee of 7,605 km over the northern hemisphere [16].

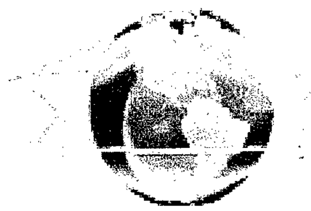

Figure 1 [16] – Concordia Orbit

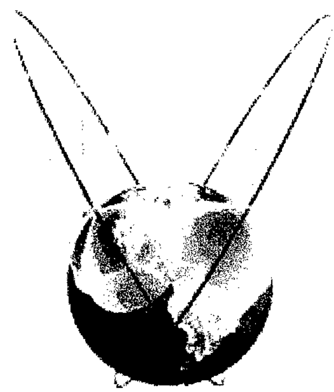

Figure 2 [16] – Borealis Orbit

5.1.1 Modified Ellipso Constellation

The model examined in this paper uses only the circular equatorial orbit with seven satellites and two elliptical helio-synchronous orbits with five satellites each. The only difference between the Ellipso concept and the model examined in this paper is the elimination of the equatorial elliptical orbit. The elliptical equatorial orbit was unnecessary to provide the coverage of the target markets described in Section 5.2.

5.1.2 System Deployment

The model company has the option to deploy the constellation all at once or to stagger the launches. By staggering the launch windows, the company can begin offering limited services using only the equatorial satellites. When ready, the remaining satellites could be launched into their respective orbits. These two variations for system deployment will be examined in detail within Section 5.5, Economic Analysis.

5.1.3 Coverage

Figure 3, shown on the next page, shows the primary coverage zones provided by the Concordia and Borealis orbits. Since over 75% of the world's population is located between 50° north and 50° south latitudes [16], the Concordia orbit offers the bulk of projected revenues. The Borealis orbit will enhance northern latitude coverage, as well as, gaining 2% more of the global population density. Figure 4, shown on the next page, depicts the global population density based on latitude.

China is currently the world's second largest telecommunications market and is expected to grow beyond the United States within the next few years [17]. China also has the world's largest population of 1.25 billion people (Jan 1999) [23]. Currently, there are 65 million subscribers of mobile services (Jan 2001) [18] and projections indicate more than 150 million by 2005 [17]. Current subscribers represent a 3.5% penetration rate based on per-capita of all Chinese people [17]. Similarly, 135 million Chinese have wireline subscriptions (Jan 2000). Wireline penetration is at

13.5% based on per-capita [17]. These indicators show the increasing demand for mobile and fixed telecom services.

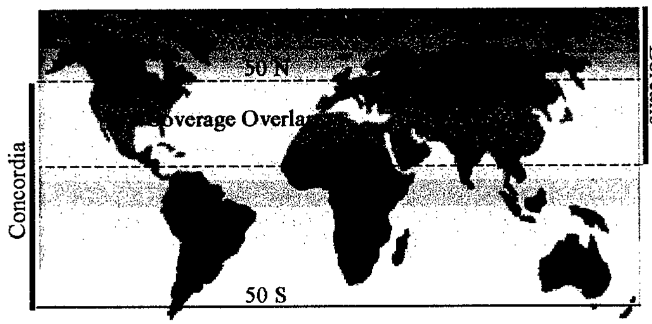

Figure 3 [16] – Coverage Zones

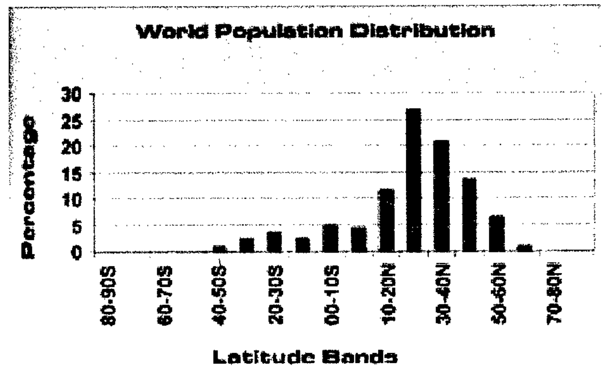

Figure 4 [16] - Global Population Density

China has several regulatory and barriers to entry issues that will need to be worked out before service can begin. A primary concern for this market is spectrum allocation. China is part of Region 3 as defined by the ITU. Any spectrum reuse within this region would need to be deconflicted through the ITU process and could potentially involve more than 30 countries within the region.

Prior to China's application to the World Trade Organization, it was illegal for foreign investors to own or operate telecommunications services within China. As part of their application, China has agreed to open their markets to foreign investment, but the caveat is the Chinese must own at least 51% of the company offering the service locally [19]. Since the model is based on offering a service to fixed and mobile subscribers, a service agreement with China controlled ChinaTelecom (which owns more than 51% of the company) would be in order. ChinaTelecom would be responsible for the ground segment of the services and would provide interconnection to their telephone network.

The orbits of the simulated LEO model cover other areas of the northern hemisphere and open many other markets for service. Future service markets include the US, Canada, Europe, Russia, parts of northern Africa and the Middle East. The majority of secondary markets already have pervasive terrestrial counterparts- fiber, microwave, broadband, etc- requiring the business model to target niche markets rather than competing head to head with the installed communications infrastructure.

Two-way voice and data communications are unrealistic in regions south of 50° south latitude because the satellites are too close to the earth at orbit perigee. However, low data rate communication from monitoring stations to the satellites is possible. These stations can be used to monitor precipitation, ozone layer depletion, or pollution levels and need to transfer that data to the businesses or universities that track and compile the data. The information could be transferred using this LEO model with a store and forward technique; collect the data on one pass and transmit to an earth station when the satellite comes into view of a ground station.

5.2 Services Offered

With the initial phase of satellite launches the model could begin to offer voice and data services in China. Services would include mobile and fixed voice services. The model can offer data rates of 28.8 kbps or higher at affordable prices and the low altitude of the satellites makes voice services competitive [16]. The model will also offer global positioning to its customers.

Competition and regulatory hurdles in other markets of the northern hemisphere (US, Europe, etc) will make business more difficult and will force the model to target remote voice and data users in niche markets. Prices that the model would have to charge may be too high for areas served by high concentrations of cellular, fiber, wireless, or broadband; but low enough for areas not yet saturated with those other services.

Fixed Satellite Service (FSS) users will have permanent antennas available for mounting on top of buildings to improve connection between users and the satellites. For MSS users, antennas can be fixed to vehicles to improve reception. For handheld users, simply avoiding large obstructions, whenever possible, will improve call connection.

5.3 Competitors in the Markets

Fiber optics, coaxial cable, and DSL are three wired competitors that would be in direct competition with LEO services. These transmission media allow for extremely large bandwidth and data rate capacities. Limitations to these services are their locations and deployment strategy. Satellite communication companies may not be able to survive head to head in terms of costs, but satellites can provide coverage to large geographical areas where terrestrial services are currently unavailable and will not be available in the near future.

Cellular communications (CDMA, 3G wireless) are getting into data and messaging, as well as, its traditional voice communications. These services are widespread and extremely cheap. A satellite company would be able to provide more reliable wireless voice and data communications by being located directly overhead and not subjected to as much natural and manmade line-of-sight (LOS) interference while allowing access to untapped markets.

Local Multipoint Distribution Services (LMDS) and Multichannel Multipoint Distribution Service (MMDS) are terrestrial wireless services that utilize satellite communication advantages, such as no direct connectivity and high data rates, but are limited by distance and spectrum availability within a region.

Direct competitors within China include Chinese sponsored terrestrial voice systems comprised of fiber optic and microwave trunking lines [20], cellular, broadband, and a Chinese sponsored satellite communications system with 55 ground stations [18]. These services will be in direct competition with our model; however, Chinese services are targeted to principal cities and industrial centers, while the new model targets the entire country. Another competitor is Globalstar, which has entered into agreements with ChinaTelecom to offer their services throughout China [21].

5.4 Economic Analysis

As with any satellite service, much of the cost occurs before services can be started and revenues generated. To be successful, a company must realize a point of economic equilibrium where total revenues equal or exceeds total costs. This equilibrium can come early or late in the lifespan of the service, so long as equilibrium is reached within the expected service life. The lifespan used for the model is seven years, the approximate lifespan of a single satellite before replacement is required.

5.4.1 Costs

There are two types of costs that are necessary to analyze the economic validity of a project: sunk and recurring. The sunk cost for a satellite system includes the charges to build, insure, and launch the satellites. The recurring cost include costs to operate and maintain the satellites, loan payments and interest on the initial cost, salaries for employees, and all other costs needed to maintain a satellite communications company.

The total sunk cost for this model's entire constellation, including five ground stations, is approximately $579 million (See Table 3). This amount is 50% less than the estimate from the Office of Telecommunications at the US Department of Commerce [22] regarding the costs of Ellipso. The model's initial cost is lower due to fewer ground stations and satellites as compared to the original Ellipso model, which provided coverage for the entire globe. Additionally, estimates use a Russian company for satellite launches, which allows deployment of more satellites per launch at lower prices. The initial cost of the ground station is related to Globalstar's ground station costs since their ground and space segments are very similar to the model defined above.

Table 3

	Quantity	$ per Unit	Comments	Total
Cost of Satellites	17	$25 M		$425 M
Cost of Insurance	4 launches	15%	- 15% of sat cost and launch	$ 72.2 M
Cost of Launch				
Russian Tsyklon 1	1	$13.5 M	- launch 4 satellites	$ 13.5 M
Russian Tsyklon 2	1	$11 M	- launch 3 satellites	$ 11 M
Russian Tsyklon 3/4	2	$16 M	- launch 5 satellites	$ 32 M
Cost of Ground Station	5	$5 M		$ 25 M
			TOTAL	$578.7 M

Annual costs are estimated to be similar to Globalstar's, which requires $5 million in operations and maintenance per ground station, totaling $25 million per year for the new model [24].

5.4.2 Revenue

Annual revenue projections are estimated on three revenue streams: High, Moderate, and Low. The high yield model assumes 150% annual growth over the first four years of service, slowing to 75% annual growth in years 5-7. The moderate yield model assumes 100% annual growth over the first four years, slowing to 50% annual growth in years 5-7. The low yield revenue model assumes 75% annual growth in the first four years, slowing in years 5-7 to 37% annual growth.

Revenues are also based on the risk-adjusted cost of capital that must be raised to fund the model and the support network. Risk adjusted cost of capital values used include: high – 12.5%, average – 10%, and low – 7.5% for each economic model created. The high value is based on a cost of capital raised mostly through equity. The average value is based on half of the money being raised through equity and equal amounts raised from bonds. The low value is based on the commercial rate of a 7-year bond plus two percent for marginal revenues. First year revenue for the model was derived from Iridium and Globalstar reported revenues and is estimated at $10 million [24]. Since no LEO company has been in business more than one year, the yearly growth percentages are estimates that represent future market potential in all markets.

5.4.3 Deployment Option Costs

There are several options available to LEO providers in order to make the model successful. Option 1 is to launch the entire satellite constellation before start of service, targeting China as the primary market and looking to gain entry into secondary markets as soon as possible. The cost of option 1 is $579 million before start of service. Option 2 is to stagger the launches of the entire constellation, offering service with the equatorial orbit initially, and following up in future years with the completion of the inclined elliptical orbits. Costs for option 2 include $230 million in year one for the first launch followed by $364 million by the end of year 2 to launch the remaining satellites. Option 3 is to lease additional capacity on earth stations from other providers. This would be done in combination with option 1 or 2.

5.4.4 Net Present Value Analysis

A Net Present Value analysis is a way to look at all options available for the deployment of a service based on costs and revenues over the life of the project with all values normalized back to current dollar figures. When the analysis is completed, any project with a positive NPV is considered a good investment.

A net present value analysis was performed on all three options with all combinations of yield and risk. Table 4 is an example of one of the twenty-seven economic analyses created when evaluating profitability of the satellite model. In Table 4, the initial costs were broken up as this represents Option 2, a staggered deployment of satellites and ground stations. The table shows the calculations based on high risk (CoC = 12.5%) illustrating yearly costs, projected revenues based on each revenue model, and present value calculations for each year.

Table 4

HIGH RISK	Year	Costs	Revenues	Cash Flow	Present Value	CoC	12.50%
	0	($229 M)		($229 M)	($229 M)		
	1	($15 M)	$10 M	($5 M)	($4.4 M)		
High Yield	2	($364 M)	$25 M	($339 M)	($268 M)		
150% annual growth	3	($15 M)	$62 M	$47 M	$33 M	NPV	$352 M
year 1-4	4	($15 M)	$156 M	$141 M	$88 M		
75% annual growth	5	($15 M)	$273 M	$258 M	$143 M		
year 5-7	6	($15 M)	$478 M	$463 M	$228 M		
	7	($15 M)	$837 M	$822 M	$360 M		

	Year	Cash Flow	Revenues	Cash Flow	Present Value	CoC	12.5%
	0	($229 M)		($229 M)	($229 M)		
	1	($15 M)	$10 M	($5 M)	($4.4 M)		
Moderate Yield	2	($364 M)	$20 M	($344 M)	($272 M)		
100% annual growth	3	($15 M)	$40 M	$25 M	$17 M	NPV	($196 M)
year 1-4	4	($15 M)	$80 M	$65 M	$40 M		
50% annual growth	5	($15 M)	$120 M	$105 M	$58 M		
year 5-7	6	($15 M)	$180 M	$165 M	$81 M		
	7	($15 M)	$270 M	$255 M	$111 M		

	Year	Cash Flow	Revenues	Cash Flow	Present Value	CoC	12.50%
	0	($229 M)		($229 M)	($229 M)		
	1	($15 M)	$10 M	($5 M)	($4.4 M)		
Low Yield	2	(364.3 M)	$17.5 M	($346.8 M)	($274 M)		
75% annual growth	3	($15 M)	$30.6 M	$15.6	$11 M	NPV	($344 M)
year 1-4	4	($15 M)	$53.6	$38.6	$24 M		
37% annual growth	5	($15 M)	$73.4	$58.4	$32.4 M		
year 5-7	6	($15 M)	$100.6 M	$85.6 M	$42.2 M		
	7	($15 M)	$137.8 M	$122.8 M	$53.8 M		

5.4.5 Economic Conclusion

Figure 5 graphs the overall net present value of all nine models evaluated. The values shown in the figure were generated as present value calculations per year and then added together to show the net present value of the option at the end of the 7-year lifespan. Two-thirds of the evaluated revenue streams and risk factor combinations result in losses to the model company.

Positive net present values are present only when the high yield revenue model is used with any of the risk-adjusted cost of capital values. The break-even point in the high yield model is between year 6 and 7. Table 5 lists the specific values for each combination of revenue model and risk-adjusted cost of capital represented in Figure 5.

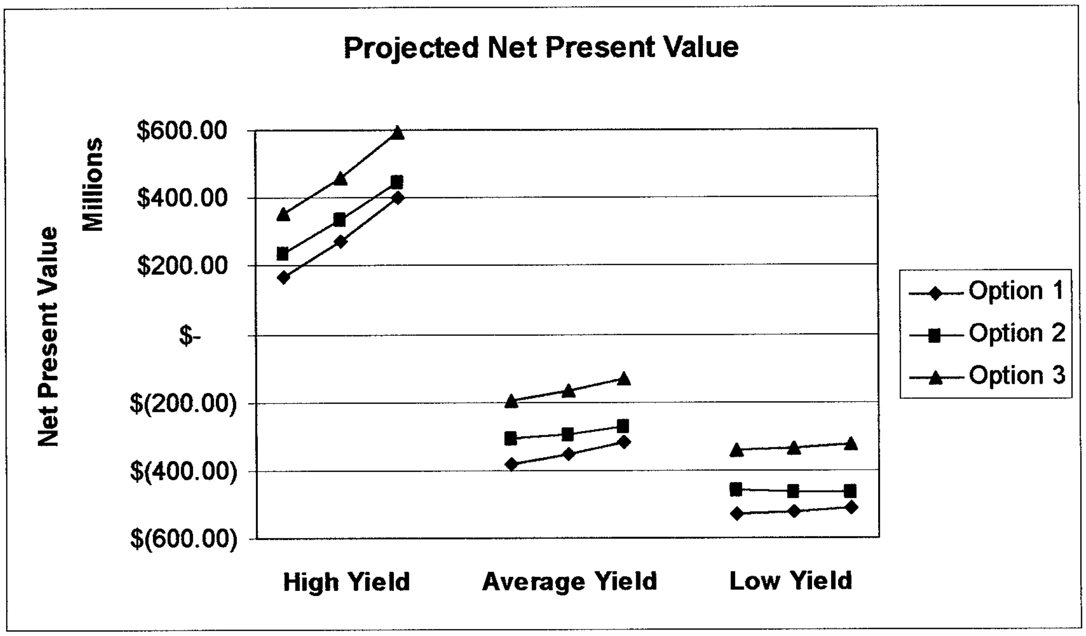

Figure 5

Table 5

		Option 1	Option 2	Option 3
High Yield	High Risk	$ 165 M	$ 238.4 M	$ 352.2 M
	Avg Risk	$ 273.7 M	$ 334.3 M	$ 461.9 M
	Low Risk	$ 401.7 M	$ 448.7 M	$ 592.4 M
Avg Yield	High Risk	$(383.4 M)	$(310.2 M)	$(196.3 M)
	Avg Risk	$(354.4 M)	$(293.8 M)	$(166.1 M)
	Low Risk	$(320.1 M)	$(273.1 M)	$(129.4 M)
Low Yield	High Risk	$(531.5 M)	$(458.2 M)	$(344.3 M)
	Avg Risk	$(523.1 M)	$(462.5 M)	$(334.9 M)
	Low Risk	$(513.2 M)	$(466.2 M)	$(322.5 M)

Leasing of satellite earth station capacity is a key way to reduce annual costs. Leasing also eliminates a portion of the regulatory hurdles since the provider must have accommodated all regulations in order to launch the service. Companies like Iridium and Globalstar may have ground stations that can be adapted to receive downlink frequencies in key markets. By utilizing existing ground stations, leasing of space and the cost of adding transmission/receiver equipment at the providers' facilities can reduce annual operating costs. This is based on $15 million annual expense while leasing over 7 years ($105 M total cost) compared to incremental costs of building and installing two new ground stations at $10 million per year over 7 years ($315 M total cost).

6 Risk Factors For The Model

In the case of a satellite service, risk is an integral part that must be understood before startup. A large portion of risk includes the launching and operating of the satellites. Insurance paid by satellite companies per launch can account 15 percent of the launch costs. Another risk is market acceptance of the new service. Will there be a market demand sufficient to remain in business? Technical risk involves efficient use of satellite resources, bandwidth, and proper operation of the satellite over its lifespan. Companies accept these risks and then must take on others outside of their control.

Frequency allocation is a risk largely out of a company's control. The ITU and the FCC must validate spectrum requirements, assuring that there is no overlap throughout the world or potential for companies to purchase spectrum licensed to other providers. Regulatory hurdles, other than the ITU and FCC, include specific regulations that must be met in serviced countries. Over flight agreements must be made, tariffs paid for termination of services, and interconnection agreements filed for connectivity into servicing countries. Apart from getting approval by the FCC and the ITU, a provider will have to deal with the regulation in the private sector of the markets targeted. In the case of the China market, can appropriate Service Level Agreements be made with Chinese controlled telecom infrastructure? These are just a few of the key risks that must be mitigated by any new satellite service provider before services can begin.

7 Conclusion

Iridium, Orbcomm, and Globalstar all failed in their attempts to provide a LEO telecommunications service. This paper has shown how global services must overcome tremendous financial, regulatory, and market pressures in order to be successful. In addition, the paper shows how LEO startup providers will have an extremely difficult time introducing a new service to the market, let alone succeed or make money. Enormous financial burdens, regulatory obstacles, and technical issues (space and ground) loom large over any new provider. The model outlined in this paper illustrated many of these hurdles and highlighted how a LEO company will not survive without extreme assistance.

After stacking the deck in favor of the model it still required an exorbitant and unrealistic revenue stream to succeed. Further assistance, including leasing capacity to lower operating costs, could come from governments or business consortiums that could help absorb some of the enormous initial costs. Therefore, a LEO company will not survive or make money in the current telecommunications market without extreme assistance.

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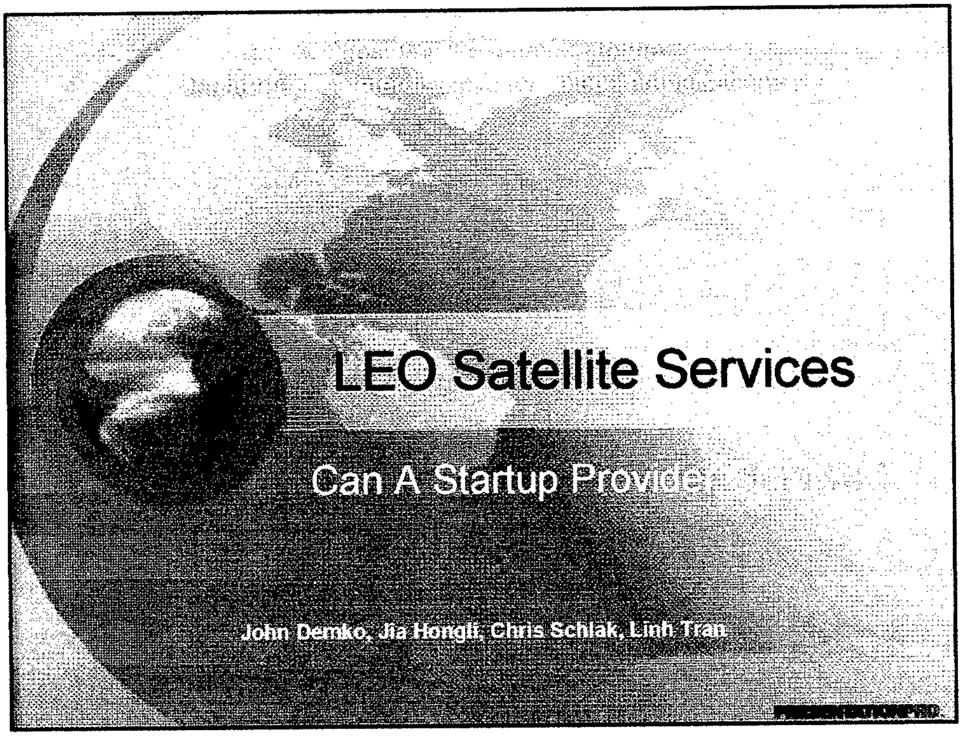
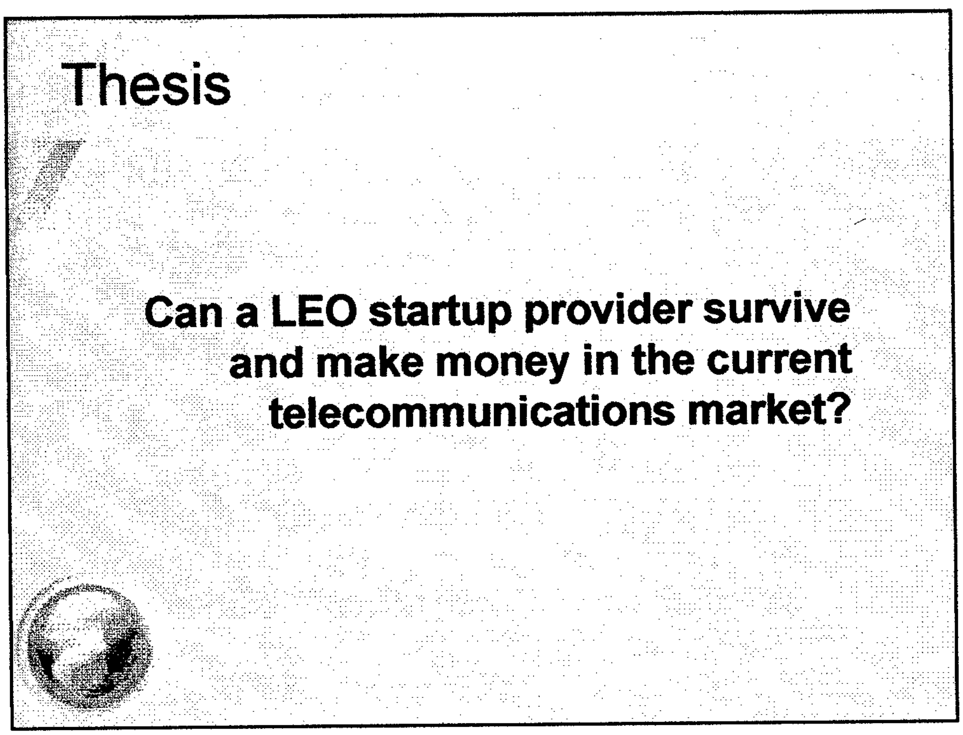

LEO Satellite Services
Can A Startup Provider
John Demko, Jia Hongli, Chris Schlak, Linh Tran


Thesis
Can a LEO startup provider survive and make money in the current telecommunications market?

Topics

- Background
- Case Studies
- Orbital Model
- Targeted Markets and Services
- Competitors to LEO Services
- Economic Analysis
- Risk
- Conclusion

Background

Then:

- 1958 – Eisenhower and SCORE
- Voice Telephony (Fixed)
- Satellite TV

Now:

- Mobile Global Telephony
- Digital Video Broadcasting
- IP Over Satellite Data Services

Case Studies - Overview

Iridium	ORBCOMM	Globalstar
Constellation of 66 LEO satellites designed to offer two-way voice commu-nication. First satellite communication system to successfully use Inter-Satellite-Links to complete an end-to-end connection.	Constellation of 35 LEO satellites to provide global messaging service. Has operating licenses in over 50 countries, representing 9% of the globe's Gross National Product.	Constellation of 48 LEO satellites designed to provide continuous global coverage for voice and low speed data.

Case Studies - Market

Iridium	ORBCOMM	Globalstar
Target industries: Aviation, construction, disaster relief, emergency, utilities, oil and gas exploration and government. Coverage in all ocean areas, air routes, landmasses and the poles.	Mobile asset tracking and monitoring (70%). Future market includes: telemetry, person-to-person global messaging, stolen vehicle recovery, and two-way Internet e-mail.	Long-distance truckers, loggers, and fishermen who are out of cell range. Industrial users: maritime, military, mining and oil exploration, and developing countries.

Case Studies - Services

Iridium	ORBCOMM	Globalstar
Voice/Paging: 2.4 kbps. Data/Fax: 2.4 to 10 kbps.	Provides affordable global wireless data and messaging for commercial and personal uses.	Two-way voice and low speed data. Fixed service in areas with inadequate telephone infrastructure.

Case Studies - Op. Status

Iridium	ORBCOMM	Globalstar
Providing voice and data services since March 2001. Currently operating with temporary licenses while the FCC processes their application.	Filed for bankruptcy in Sept 2000. New Orbcomm provides global data services through 31 satell-ites from the first gener-ation constellation.	Currently operating 38 gateways worldwide, servicing more than 100 countries on 6 continents.

Case Studies - Cost

Iridium	ORBCOMM	Globalstar
Corporate: $25 million investment. $7 million per month to operate. Subscriber: less than $1.50/minute. $900-$1500 per handset.	$7.5 million investment, $900k monthly operating expenses. Each wireless device costs $995. Charges are $0.01 per character.	Initial cost of system was $3 billion for space and ground segment. Tri-mode phone costs $900. Airtime ranges from $0.89-$1.29/minute.

Case Studies - Regulation

Iridium	ORBCOMM	Globalstar
In the process of transferring all of the licenses of the old Iridium LLC to the new Iridium. Currently operating while the license transfer process proceeds.	New Orbcomm has regulatory approval in virtually every major economic market in the world.	Globalstar began service as a non-common carrier within the U.S. in 1999 and abides by ITU regulations for spectrum reuse in various ITU regions.

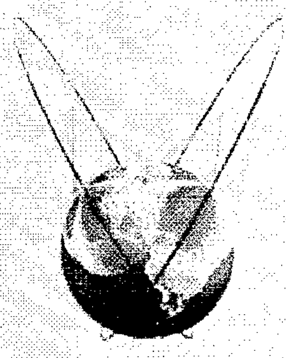
Case Studies

- Common Causes of Failures
  - – Building Fade
  - – Poor Business Plan
  - – Low Market Demand
    - Equipment and Subscription Costs
  - – Large Initial Investment

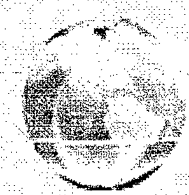
Orbital Model - Ellipso

- New Model Based on Ellipso Concept
- Why Ellipso
  - – Excellent Coverage of World Population
  - – Minimal Number of Satellites

Orbital Model -Orbits



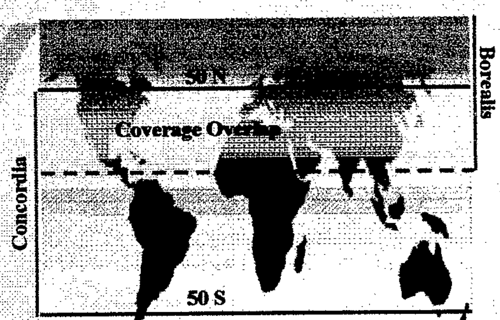
Borealis Orbit



Concordia Orbit

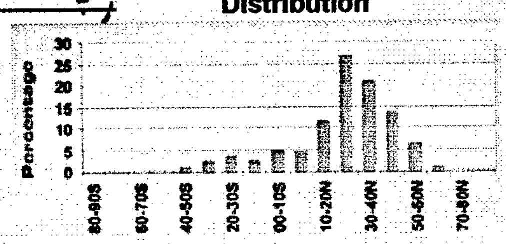
Graphics Source: Ellipso (www.ellipso.com)

Orbital Model - Coverage



Global Coverage Zones

World Population Distribution



Graphics Source: Ellipso (www.ellipso.com)

Targeted Markets and Services

- Primary
  - China
  - Voice and Data
- Secondary
  - Northern Hemisphere
  - Voice and Data
- Tertiary
  - Remote Monitoring and Low BW Data
  - GPS

Competitors to LEO Services

- China
  - State Sponsored Voice Infrastructure
    - Fiber Optic / Microwave Trunks
    - National Satellite System
  - Targeted Towards Population Centers
- Northern Hemisphere
  - Fiber Optic, Microwave, Wireless, and Broadband
- Tertiary
  - Other LEO Satellite Providers

Economic Analysis

- Initial Costs

	Quantity	$ per Unit	Total
Cost of Satellites	17	$25 M	$425 M
Cost of Insurance	4 launches	15%	$72 M
Cost of Launch			
Russian Tsyklon 1	1	$13.5 M	$13.5 M
Russian Tsyklon 2	1	$11 M	$11 M
Russian Tsyklon 3/4	2	$16 M	$32 M
Cost of Ground Station	5	$5 M	$25 M
		Total	$579 M

- Recurring Costs
  - $5 M Operations and Maintenance per Ground Station

Economic Analysis

- Net Present Value Analysis
- Launch Options
  - Launch Everything in Year 0
  - Staggered Launch in Year 0 and Year 2
  - Staggered Launch and Lease Facilities
- Risk Adjusted Cost of Capital
  - High Risk → 12.5% (Equity)
  - Avg Risk → 10% (Equity and Bonds)
  - Low Risk → 7.5% (Bonds)

Economic Analysis

- Revenue Models
  - Year 1 estimated $10 M revenue
  - High
    - 150% annual growth year 1-4
    - 75% annual growth year 5-7
  - Moderate
    - 100% annual growth year 1-4
    - 50% annual growth year 5-7
  - Low
    - 75% annual growth year 1-4
    - 38% annual growth year 5-7

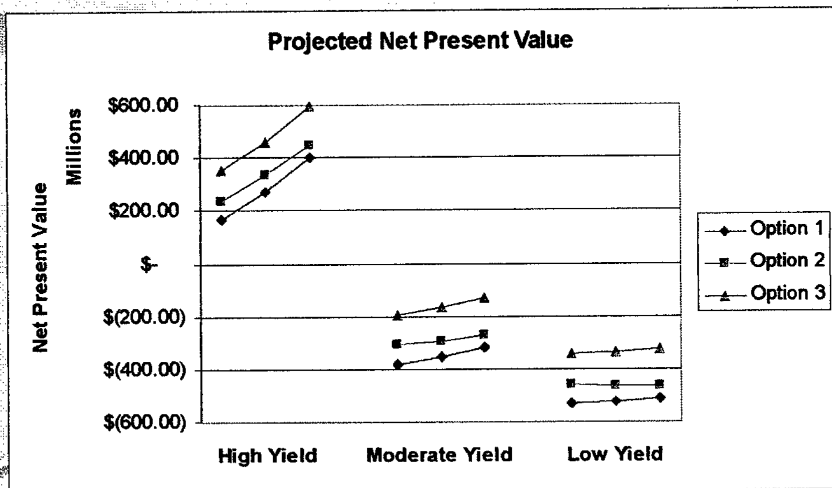
Economic Analysis

- Sample NPV Table

HIGH RISK	Year	Costs	Revenues	Cash Flow	Present Value		
						CoC	12.50%
	0	-$579 M		-$579 M	-$579 M		
	1	-$15 M	$10 M	-$5 M	-$4 M		
High Yield	2	-$25 M	$25 M	-	-		
150% annual	3	-$35 M	$63 M	$28 M	$19 M	NPV	$165 M
growth year 1-4	4	-$45 M	$156 M	$111 M	$69 M		
75% annual	5	-$55 M	$273 M	$218 M	$121 M		
growth year 5-7	6	-$65 M	$479 M	$414 M	$204 M		
	7	-$75 M	$837 M	$762 M	$334 M		

- Option 1
  - All Costs Paid in Year 0
- High Risk/High Yield Example

Economic Analysis



Risk

- Integral Part of Service Model
  - Business Plan
  - Regulatory Hurdles
  - Barriers to Entry
  - Launching and Operating
  - Market Acceptance

Conclusion

- Can a Startup LEO Service Provider Survive?
  - No, not Without Extreme Assistance!
- However:
  - Need to Overcome Tremendous Financial, Regulatory, and Market Pressures
  - Leasing of Facilities and Capacity
  - Government Funding or Business Consortium Investment

QUESTIONS?

LEO Satellite Services

Can A Startup Provider

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